

FORM PTO-1390 (Modified) (REV 11-2000)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		ATTORNEY'S DOCKET NUMBER 221180US2PCT	
INTERNATIONAL APPLICATION NO. PCT/JP00/05295		U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR) 10/089149	
INTERNATIONAL FILING DATE 08 AUGUST 2000		PRIORITY DATE CLAIMED 30 SEPTEMBER 1999	
TITLE OF INVENTION STETHOSCOPE			
APPLICANT(S) FOR DO/EO/US Tsutomu NAKADA			
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information: <ol style="list-style-type: none"> 1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. 2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. 3. <input checked="" type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (24) indicated below. 4. <input checked="" type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (Article 31). 5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371 (c) (2)) <ol style="list-style-type: none"> a. <input type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau). b. <input checked="" type="checkbox"/> has been communicated by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US). 6. <input checked="" type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)). <ol style="list-style-type: none"> a. <input checked="" type="checkbox"/> is attached hereto. b. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4). 7. <input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3)) <ol style="list-style-type: none"> a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau). b. <input type="checkbox"/> have been communicated by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input checked="" type="checkbox"/> have not been made and will not be made. 8. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). 9. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)). 10. <input checked="" type="checkbox"/> An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)). 11. <input checked="" type="checkbox"/> A copy of the International Preliminary Examination Report (PCT/IPEA/409). 12. <input checked="" type="checkbox"/> A copy of the International Search Report (PCT/ISA/210). <p>Items 13 to 20 below concern document(s) or information included:</p> <ol style="list-style-type: none"> 13. <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98. 14. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included. 15. <input type="checkbox"/> A FIRST preliminary amendment. 16. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. 17. <input type="checkbox"/> A substitute specification. 18. <input type="checkbox"/> A change of power of attorney and/or address letter. 19. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825. 20. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4). 21. <input type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4). 22. <input type="checkbox"/> Certificate of Mailing by Express Mail 23. <input checked="" type="checkbox"/> Other items or information: <p style="margin-left: 20px;"> Notice of Priority / PCT/IB/304 / PCT/IB/308 PTO-1449 / Drawings (2 sheets) Amended Sheets (pages 3, 3a, 12 & 12a) </p> 			

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 1.101) 10/089149		INTERNATIONAL APPLICATION NO. PCT/JP00/05295		ATTORNEY'S DOCKET NUMBER 221180US2PCT	
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24. The following fees are submitted: BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) : <input type="checkbox"/> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO \$1040.00 <input checked="" type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$890.00 <input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$740.00 <input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$710.00 <input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00 ENTER APPROPRIATE BASIC FEE AMOUNT =				CALCULATIONS PTO USE ONLY	
				\$890.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).				\$0.00	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	5 - 20 =	0	x \$18.00	\$0.00	
Independent claims	1 - 3 =	0	x \$84.00	\$0.00	
Multiple Dependent Claims (check if applicable). <input type="checkbox"/>				\$0.00	
TOTAL OF ABOVE CALCULATIONS =				\$890.00	
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2.				\$0.00	
SUBTOTAL =				\$890.00	
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).				\$0.00	
TOTAL NATIONAL FEE =				\$890.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable). <input type="checkbox"/>				\$0.00	
TOTAL FEES ENCLOSED =				\$890.00	
				Amount to be:	\$
				refunded	\$
				charged	\$

a. ☒ A check in the amount of **\$890.00** to cover the above fees is enclosed.


b. ☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **15-0030** A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.


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 REGISTRATION NUMBER
March 27 2002
 DATE

2/p1b

DESCRIPTION

STETHOSCOPE

TECHNICAL FIELD

The present invention relates to a stethoscope, which is an instrument used by doctors in medical settings.

BACKGROUND ART

Techniques for acquiring data regarding hemoglobin of an organism by use of near-infrared light have been well known (in general, such techniques are collectively called "near-infrared spectroscopy (NIRS)").

One example application thereof is an oxymeter, which has been widely used. In recent years, functional imaging for noninvasively detecting cerebral function through detection of a change in the cerebral circulation blood flow has been widely noticed. This technique has been widely used in, for example, positron emission tomography (PET), which utilizes water labeled with O^{15} , and in a magnetic resonance imaging (BOLD-fMRI) which utilizes the magnetic susceptibility effect of deoxy hemoglobin. Development of a functional imaging technique (called optical CT) which utilizes near-infrared light has been pursued, because such functional imaging enables obtainment of hemoglobin information by use of near-infrared light. However, this functional imaging technique cannot be said to have been

established.

Diagnostic apparatuses and tools can be divided into the following three categories.

(1) A large apparatus such as those used in connection with the above-mentioned PET and MRI, which requires a patient to go to a place where the apparatus is installed in order to receive an examination.

(2) A small apparatus, such as an electrocardiograph, an electroencephalograph, or an oxymeter, which is disposed at a bedside or in an ambulance, or a portable apparatus which is transported to the location of a patient.

(3) An instrument, such as a stethoscope, which a medical worker always carries on his person.

DISCLOSURE OF THE INVENTION

To date, the stethoscope is the only useful instrument which is categorized in the above-mentioned category (3). Meanwhile, in the above-mentioned category (2), apparatuses, such as an oxymeter, which utilize the above-described near-infrared light have been established. The concept of optical CT belongs to the above-mentioned category (1) or (2).

In view of the forgoing, an object of the present invention is to provide a simple, always-portable stethoscope for enabling accurate diagnosis.

In order to achieve the above object, the present invention provides the following:

[1] A stethoscope which comprises a probe section for

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noninvasively irradiating a diseased part with near-infrared light, the probe having radiation and light-receiving fibers; a control device connected to the probe section via a lead wire, the control device including a semiconductor laser light source connected to the radiation fiber, an optical detector connected to the light-receiving fiber, a controller for detecting a change in cerebral circulation blood flow on the basis of data output from the probe section, and a sound source device for converting the change in cerebral circulation blood flow to sound pulses; and a pair of lead wires and receivers connected to the sound source device of the control device, wherein auscultation is performed on the basis of the sound pulses from the sound source device in order to diagnose a change in cerebral function.

[2] A stethoscope according to [1] above, wherein the near-infrared light includes two wavelengths.

[3] A stethoscope according to [1] above, wherein the near-infrared light includes three wavelengths.

[4] A stethoscope according to [3] above, wherein the near-infrared light includes wavelengths of 760 nm, 800 nm, and 830 nm.

[5] A stethoscope according to [1] above, wherein the change in cerebral circulation blood flow is a change in total hemoglobin (t-Hb) or oxygen saturation rate of hemoglobin (rSO₂).

The present invention enables provision of a "functional stethoscope" which noninvasively radiates near-

infrared light to a diseased part, and detects a change in the cerebral circulation blood flow, for example. The change is heard as sound pulse modulation to examine a change in the cerebral function. More specifically, a light beam of three wavelengths $\lambda = 760, 800, 830$ nm which is generated by a semiconductor laser light source is applied to a diseased

part; and a change in reflection data is converted to a change in pulse frequency of the sound of constant pitch and volume, to thereby enable a doctor to carry out auscultation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic structural view of a stethoscope according to an embodiment of the present invention.

FIG. 2 is a block diagram of the stethoscope according to the embodiment of the present invention.

FIG. 3 is a structural view of a radiation/light-receiving fiber of a probe section of the stethoscope according to the embodiment of the present invention.

FIG. 4 is a graph showing examples of activation by higher-order cerebral activities.

BEST MODE FOR CARRYING OUT THE INVENTION

An embodiment of the present invention will next be described in detail.

A stethoscope of the present invention is adapted to detect a change in total hemoglobin (t-Hb) or oxygen saturation (regional oxygen O_2 saturation (rSO_2)) of hemoglobin and output the change in the form of sound information. The stethoscope of the present invention can be integrated with an ordinary stethoscope to thereby constitute a "smart stethoscope."

The stethoscope of the present invention is mainly used as a "functional stethoscope" which can confirm a local

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analysis without accurate quantification.

The following description of the present invention is confined to hemoglobin.

Actual optical absorbency, which is detected through sensing of reflection of radiated light, changes in accordance with the total hemoglobin t-Hb and the oxygen saturation rate of hemoglobin in a tissue under examination. Accordingly, detection of optical absorbency at a single wavelength cannot determine whether the total hemoglobin or the oxygen saturation rate changes. In view of the foregoing, optical absorbency is detected by use of at least two different wavelengths, and both the total hemoglobin and the oxygen saturation rate are estimated. In actuality, more accurate values can be calculated by use of three wavelengths. However, satisfactory results are obtained by use of two wavelengths, and in some cases use of two wavelengths is more advantageous than use of three wavelengths. Hereinafter, the embodiment will be described with reference to a calculation formula for the case in which three wavelengths are used.

One important application of the present invention is determination of "cerebral function." In the brain, cerebral functions are present in a localized manner. That is, a certain function is allocated to a certain site of the brain. At the certain site of the brain used, various metabolic changes (e.g., an increase in blood flow rate or an increase in glucose consumption) occurs. Such metabolic changes which occur at specific brain sites due to specific activities are

$$\Delta t\text{-Hb} = 1.6 \cdot \Delta A_{780} - 5.8 \cdot \Delta A_{800} + 4.2 \cdot \Delta A_{830}.$$

Similarly, change in rSO_2 can be obtained by an approximate expression, as follows:

$$\Delta rSO_2 = (-3.0 \cdot \Delta A_{800} + 3.0 \cdot \Delta A_{830}) / (1.6 \cdot \Delta A_{780} - 2.8 \cdot \Delta A_{800} + 1.2 \cdot \Delta A_{830}).$$

In the expressions, each of the subscripts represents a corresponding wavelength of near-infrared light (nm). By changeover of a changeover switch, the total hemoglobin (t-Hb) or the oxygen saturation rate (rSO_2) of hemoglobin can be measured selectively.

FIG. 1 is a schematic structural view of a stethoscope according to an embodiment of the present invention. FIG. 2 is a block diagram of the stethoscope. FIG. 3 is a structural view of a radiation/light-receiving fiber of a probe section of the stethoscope.

In these drawings, reference numeral 11 denotes a radiation/light-receiving fiber which serves as a probe section; 12 and 13 each denote an optical amplifier; 15 denotes a lead wire; 21 denotes a control device; 22 denotes a semiconductor laser source; 23 denotes a calibration control device; 24 denotes an optical detector; 25 denotes a data processing device (IC); 26 denotes a sound source device; and 27 denotes a changeover switch. Through use of this changeover switch 27, one of total hemoglobin (t-Hb) or the oxygen saturation rate (rSO_2) of hemoglobin is selected as a value to be detected. In the drawing, a power source is omitted. Reference numeral 31 denotes a lead wire connected

to the sound source device 26; and 32 denotes a receiver which a doctor uses to hear sound.

As shown in FIG. 3, the radiation/light-receiving fiber which serves as a probe section of the stethoscope has a configuration such that a radiation fiber is disposed at the center, and reception fibers are disposed around the radiation fiber.

Diagnosis by use of the stethoscope is carried out as follows. That is, light of three wavelengths ($\lambda = 760, 800, 830$ nm) is radiated to a diseased portion; and the control device 21 outputs a change in the reflection data. The sound source device 26 converts the change to a change in pulse frequency of a sound having a constant pitch and volume. A doctor listens to the sound from the receiver 32.

A specific operation of the sound source device 26 will now be described.

FIG. 4 shows changes in the rSO_2 signal in the form of a graph. In the present invention, this change (in actuality, change in the selected one of t-Hb and rSO_2) is indicated in the form of sound (similar to conversion between a diaphragm type and a bell type of an ordinary stethoscope).

In general, the following methods are used in order to indicate increase and decrease of a measured value by means of sound.

- (1) Increase the volume of sound.
- (2) Increase the pitch of sound.

However, both are difficult to sense.

In view of the foregoing, in the present invention, rise and fall of a measured value is converted to a change in the pulse frequency of a certain sound. In other words, the above conversion is similar to conversion from an "amplitude-modulated" signal to a "frequency-modulated" signal. That is, the pulse frequency of a certain sound is changed in accordance with a measured value as follows (Pi represents a sound):

Pi Pi Pi Pi
 Pi Pi Pi Pi Pi Pi Pi

In this case, the latter shows that the measured value has increased.

In consideration of the psychological resolution of a medical worker, the sound source device 26 outputs not a sound used in a conventional oxymeter or the like but a sound having a constant pitch and roundness (sound corresponding to action potential in physiology). A change in t-Hb or rSO₂ is converted to a change in pulse frequency of sound (as in the case of neuron firing rate), and a medical worker detects the change by listening to the sound.

As described above, the stethoscope of the present invention is a useful, always-portable type instrument, which has not been introduced to doctors or other medical personnel since the invention of the classical stethoscope. The importance of the present invention is remarkable in consideration of the role which classical stethoscopes, which convey sound information only, have played in the medical

field, and in view that the classical stethoscope is still the most important instrument used for diagnosis.

The present invention is not limited to the embodiments described above. Numerous modifications and variations of the present invention are possible in light of the spirit of the present invention, and they are not excluded from the scope of the present invention.

As described in detail, the present invention can provide a simple, always-portable stethoscope for enabling accurate diagnosis.

INDUSTRIAL APPLICABILITY

The present invention is suitable for the field of medical auscultatory devices, and can be applied to a functional stethoscope which enables a user to confirm a local activation caused by a cerebral function at a bedside.

CLAIMS

1. (amended) 1. A stethoscope comprising:

(a) a probe section for noninvasively irradiating a diseased part with near-infrared light, the probe having radiation and light-receiving fibers;

(b) a control device connected to the probe section via a lead wire, the control device including a semiconductor laser light source connected to the radiation fiber, an optical detector connected to the light-receiving fiber, a controller for detecting a change in cerebral circulation blood flow on the basis of data output from the probe section, and a sound source device for converting the change in cerebral circulation blood flow to sound pulses; and

(c) a pair of lead wires and receivers connected to the sound source device of the control device, wherein

(d) auscultation is performed on the basis of the sound pulses from the sound source device in order to diagnose a change in cerebral function.

2. A stethoscope according to claim 1, wherein the near-infrared light includes two wavelengths.

3. A stethoscope according to claim 1, wherein the near-infrared light includes three wavelengths.

4. A stethoscope according to claim 3, wherein the near-infrared light includes wavelengths of 760 nm, 800 nm, and 830 nm.

5. A stethoscope according to claim 1, wherein the change in cerebral circulation blood flow is a change in total

ABSTRACT

A simple always-portable stethoscope for enabling accurate diagnosis. A radiation/light-receiving fiber (11) serving as a probe part for noninvasively irradiating a diseased part with near-infrared light is applied to the diseased part so as to measure, e.g., a change of the cerebral circulation blood flow. The change is hard as sound pulse modulation to examine the change of the cerebral function. For example, a light beam of three wavelengths $\lambda = 760, 800, 830$ nm from a semiconductor laser light source (22) is applied to the diseased part, the reflection data from the diseased part is processed by a control device (21), and the doctor can make a diagnosis with the doctor's ears by hearing with a receiver (32) the change as the change of the frequency of the sound the pitch and volume of which are constant.

FIG. 1

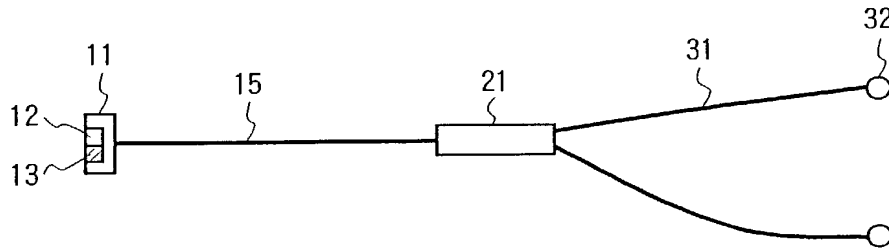


FIG. 2

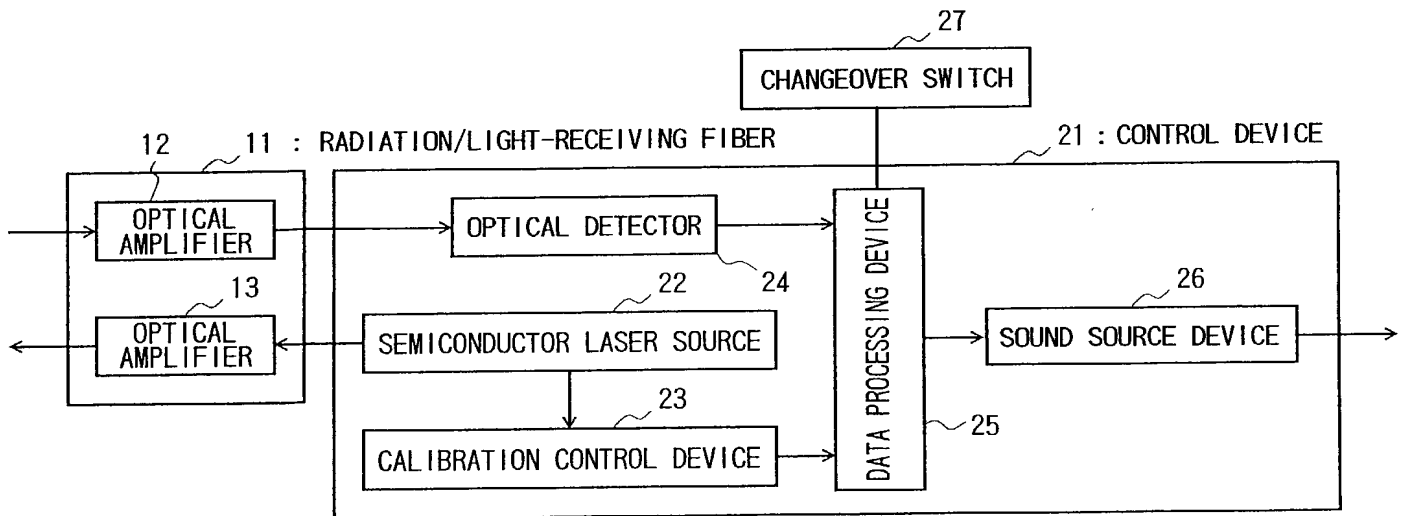


FIG. 3

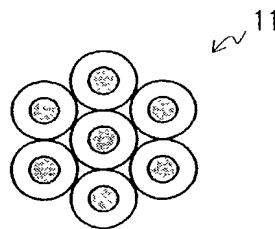
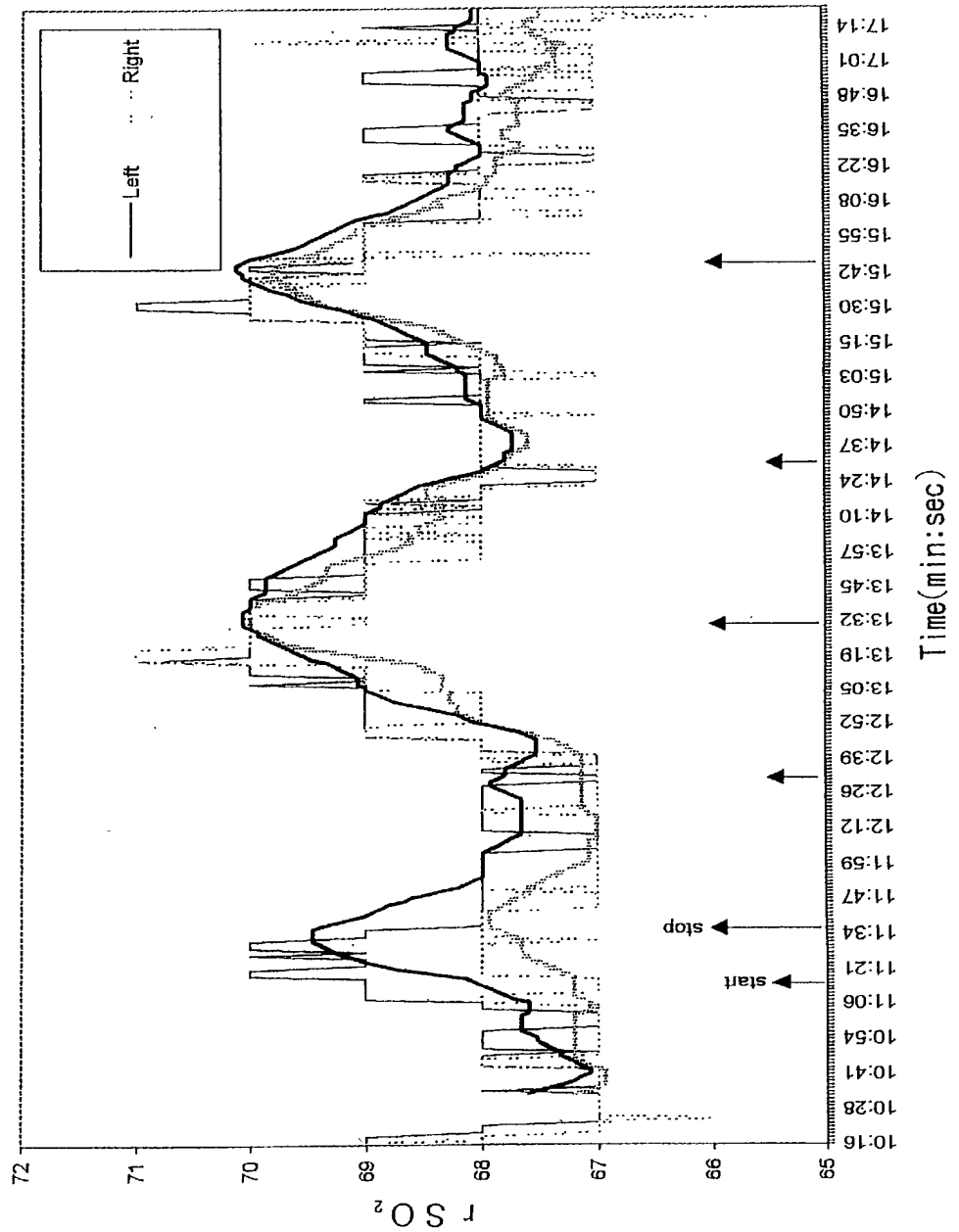


FIG. 4



Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者（下記の名称が複数の場合）であると信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled.

STETHOSCOPE

上記発明の明細書は、

- ☐ 本書に添付されています。
- ☐ ____月____日に提出され、米国出願番号または特許協定条約国際出願番号を____とし、
(該当する場合) ____に訂正されました。

the specification of which

- ☒ is attached hereto.
- ☒ was filed on August 8, 2000
as United States Application Number or
PCT International Application Number
PCT/JP00/05295 and was amended on
March 26, 2001 (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されたとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

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(弁護士、または代理人の指名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: *(list name and registration number)*

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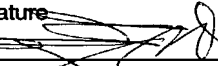

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(Supply similar information and signature for third and subsequent joint inventors.)